Motorcycle Brake System

The present invention relates to a motorcycle brake system according to the preamble of patent claim 1.

EP 1 176 075 A2 discloses a motorcycle brake system of this type. This brake system has a complex structure and is hence expensive because it operates according to the return principle. Therefore, brake systems of this type are not employed in low-cost motorcycles so that usually the brake system in motorcycles of the lower price segment is not equipped with brake slip control.

In view of the above, there is the general risk in motorcycles of the lower price segment that the front wheel tends to lock on bad, in particular, wet roads and when a brake operation is initiated abruptly. In the worst case, the front wheel will lock, and the cornering force will thus be lost. Especially as regards motorcycles, insufficient driving stability causes an extremely critical condition and represents a great risk potential for the driver in view of the danger of falling.

In view of the above, an object of the invention is to develop a low-cost, functionally reliable brake system with brake slip control which is especially well suited for the application in motorcycles of the low and medium price level.

This object is achieved for a motorcycle brake system of the indicated type with the characterizing features of patent claim 1.

Further features and advantages of the invention can be seen in the sub claims and the subsequent description of an embodiment by way of two drawings.

In the drawings:

Figure 1 is a schematic view of the arrangement of the motorcycle brake system of the invention for controlling the brake slip at the front-wheel brake of a motorcycle;

Figure 2 is the design of a favorable front-wheel brake unit for the motorcycle brake system of Figure 1 in a schematically illustrated connection to the front-wheel brake.

Figure 1 shows a schematic side view of a motorcycle, the front wheel of which is equipped with a hydraulically operable wheel brake 5 and a wheel rotational speed sensor 6. A so-called front-wheel brake unit 8 being an essential component of the motorcycle brake system is mounted at the steering rod 9, said unit being connected to the brake caliper of the wheel brake 5 by way of the illustrated brake line 20 of the front-wheel brake circuit 2. The front-wheel brake unit 8 connects to the electrical wiring system 1 of the motorcycle for the supply with electric energy.

Further, Figure 1 illustrates a conventional hydraulic rear-wheel brake circuit 4, comprising a master brake cylinder 3, which can be operated proportionally to pedal force and connects to a disc brake by way of the brake line of the rear-wheel brake circuit 4.

Although not shown in Figure 1, the rear-wheel brake can be operated by way of a linkage or Bowden cable arranged between the brake pedal 11 and the wheel brake 14, as well as purely mechanically, in the simplest embodiment of the rear-wheel brake circuit 4, so that when viewing the front-wheel brake circuit 2 that will be explained in more detail by reference to Figure 2, an especially straightforward motorcycle brake system with brake slip control is achieved, especially in connection with the rear-wheel brake circuit 4 that has an appropriately efficient design.

Figure 2 shows the details of the motorcycle brake system at the hydraulically operable front-wheel brake circuit 2 which are required for brake slip control and integrated in the so-called front-wheel brake unit 8. The front-wheel brake unit 8 includes a manually operable master brake cylinder 7, a brake fluid supply tank 19 connected to the master brake cylinder 7, and each one electromagnetically operable inlet valve and outlet valve 21, 22 for brake slip control in the front-wheel brake circuit 2.

The brake pressure, which is manually produced in the brake line 20, can be limited by the inlet valve 21 at any time. The brake pressure reduction in the front-wheel brake 5 takes place by way of the outlet valve 22 directly into the supply tank 19, for what reason the outlet valve 22 is arranged in

parallel to the inlet valve 21 between the front-wheel brake circuit 2 and the brake fluid supply tank 19 in a hydraulic connection.

Thus, Figure 2 depicts in a favorable manner that the master brake cylinder 7 is structurally grouped with the supply tank 19, with the inlet and outlet valves 21, 22, and a travel sensor 10 to form an independently manageable, operable front-wheel brake unit 8, and the front-wheel brake unit 8 can be activated exclusively by means of a hand brake lever 12 that acts upon the master brake cylinder 7 for the purpose of slip-free brake operation as well as for pressure increase in a brake slip control action.

For the electric activation of the inlet and outlet valves 21, 22, a control device 24 is further provided, which is an integral component of the front-wheel brake unit 8. Preferably for the purpose of electrical contacting, the control device 24 is slipped onto the inlet and outlet valves 21, 22 and connected to the electrical wiring system 1 for power supply.

To attach the front-wheel brake unit 8 to a steering rod 9, the front-wheel brake unit includes a holding portion with a through-bore 25.

Hence, the invention provides that brake slip control is exclusively limited to the front-wheel brake 5 which regularly has to transmit high brake forces onto the roadway, and the pressure increase in the front-wheel brake circuit 2, being an essential element of the invention, is determined dependent on the switching position of the inlet and outlet valves 21, 22 by the brake fluid volume which is available in the master

brake cylinder 7 and can be displaced exclusively manually into the front-wheel brake circuit 2.

To avoid exhaustion of the brake fluid volume during a brake slip control operation, as brake fluid can escape through the outlet valve 22 to the supply tank in the pressure reduction phase, provisions are made to monitor the brake fluid volume prevailing in the master brake cylinder 7.

In an expedient embodiment, the brake fluid volume in the master brake cylinder 7 is monitored by sensing the position of a working piston 13 in the master brake cylinder 7 that displaces the brake fluid into the front-wheel brake circuit 2, for what purpose the master brake cylinder 7 is equipped with the travel sensor 10.

If desired or required, the travel sensor 10 can be omitted when, based on the valve operation cycles, a so-called volume consumption model is reproduced for the slip-controlled front-wheel brake circuit 2 and stored as a performance graph in the control device 24. However, additional software is required with regard to this method in order to reach in good approximation the comparatively simple and precise volume consumption detection of the travel sensor 10. Hence, this alternative will not be referred to in detail herein and, rather, the significance of the travel sensor 10 will be pointed out in the following.

In order to evaluate the signals of the travel sensor 10, the electronic control device 24 is equipped with an appropriate evaluating circuit; and the control algorithms provided for the inlet and outlet valves 21, 22 will be modified, depending

on the result of the evaluation of the signals of the travel sensor 10 by means of the control device 24, in such a fashion that the brake fluid volume in the master brake cylinder 7 can be dosed in a suitable manner during brake slip control and, thus, cannot be displaced prematurely through the inlet and outlet valves 21, 22 into the front-wheel brake circuit 2 or the supply tank 19, respectively. Favorably, this achieves a comfortable, only gradually rising actuating travel at the hand brake level 12, without the risk of premature exhaustion of the brake fluid volume in the master brake cylinder 7.

During the brake slip control operation, the brake fluid volume available in the master brake cylinder 7 can be reduced until a reserve volume required for the minimum braking deceleration of the motorcycle. When the reserve volume is reached, the travel sensor 10 causes the brake slip control at the front-wheel brake circuit 2 that is initiated by the control device 24 to be discontinued in that the inlet and outlet valves 21, 22 are no longer actuated electromagnetically. The inlet and outlet valves 21, 22 will then remain in their basic position, as shown, in which there is an unhindered pressure fluid connection to the front-wheel brake 5 through the inlet valve 21, however, escape of the pressure fluid out of the front-wheel brake circuit 2 into the supply tank 19 is prevented due to the closed position of the outlet valve 22.

In the embodiment at issue, pressure buildup takes place in the front-axle circuit 2 as soon as the central valve 16, which is kept mechanically open by means of a cylindrical pin 15 in the working piston 13, is closed after a short working piston stroke X due to actuation of the hand brake lever 12,

with the result that the hydraulic connection of the supply reservoir 19 with the pressure chamber 17 in the master brake cylinder 7 is separated.

Alternatively, the central valve 16 can also be replaced by a sleeve-type valve at the working piston 13, which valve would override, and thereby isolate, a breathering bore connected to the supply tank 19 after a minimum working piston stroke X.

Apart from the types of valve constructions described hereinabove, the pressure chamber 17 of the master cylinder 7 is thus in any case separated from the supply tank 19 at the commencement of the actuation of the working piston 13. The wheel brake 5 is then connected hydraulically exclusively to the pressure chamber 17 of the master brake cylinder 7 by way of the brake line 20 and the normally open inlet valve 21. Manual pressure buildup in the front-wheel brake circuit 2 may thus take place.

Principally, the following applies:

1. An imminent locked condition of the front wheel 23 is reliably detected by means of the wheel rotational speed sensor 6 and its evaluation of signals in the control device 24. As mentioned hereinabove, the inlet valve 21 is electromagnetically closed by way of the control device 24 in order to stop further pressure buildup in the front-wheel circuit 2.

2. Should further pressure reduction in the front-wheel brake circuit 2 be additionally necessary to reduce the imminent locked condition, this aim is achieved by

opening the normally closed outlet valve 22 that is connectable to the supply tank 19. The outlet valve 22 will be closed again as soon as the wheel acceleration rises beyond a defined value again. The inlet valve 21 remains closed in the pressure reduction phase so that the master cylinder pressure generated in the pressure chamber 17 by means of the hand brake lever 12 cannot propagate into the front-wheel brake circuit 2.

3. When the detected slip values allow pressure buildup in the front-wheel brake circuit 2 again, the inlet valve 21 will be opened within time limits in conformity with the demand of the slip controller integrated in the control device 24. The differential volume necessary for pressure buildup is now taken from the pressure chamber 17 of the master brake cylinder 13. As this occurs, the working piston stroke changes depending on the differential volume removed, i.e. the manually operated working piston 13 acts as a delivery pump for the front-wheel circuit 2 in the pressure increase phases.

As the brake fluid volume prevailing in the master brake cylinder 7 is limited, the initially explained modification of the control algorithms of the slip controller is used to minimize the volume consumption in the master brake cylinder 7 and, thus, the resulting working piston stroke X. The modification of the control algorithms allows dealing with the limited brake fluid volume in the pressure chamber 17 of the master brake cylinder 7 in a correspondingly economical fashion.

Since the travel sensor 10 is permanently detecting the position of the working piston 13, it is possible to calculate the volume being 'consumed' for the purpose of brake slip control at any time by means of the control device 24, and to disable the slip controller in a borderline case when a defined reserve stroke X_R is reached. The reserve volume then remaining in the pressure chamber 17 is chosen in such a way as to ensure full pressure buildup or the minimum deceleration by the front-wheel circuit (2) which is mandated by law for motorcycles.

Summarizing one can say that:

The brake system described is based on the integration of a low-cost ABS control system without a pump into the front-wheel brake circuit 2 of a motorcycle brake system, without taking influence on the rear-axle brake circuit 4 of conventional design.

The ABS control system is favorably integrated into a brake actuation unit of the front-wheel brake circuit 2 and forms a compact front-wheel brake unit 8. Optionally, the ABS control system can also be integrated as an independent construction unit into the front-wheel brake circuit 2.

This system is a so-called open-loop brake system because pressure reduction is carried out through the outlet valve directly into the supply tank 19, by way of which the pressure chamber 17 can be filled anew when the working piston 13 stays in the non-actuated basic position. For reasons of cost and integration, pressure is built up during brake slip control without using an electrically driven hydraulic pump, there

being no need for a low-pressure accumulator due to the pressure reduction into the supply tank 19.

Finally, it should not be left unmentioned that, of course, the described features of the front-wheel brake circuit, with a corresponding additional effort, can be implemented on the rear-wheel brake circuit, or, respectively, the features of the front-wheel brake circuit can be added to the rear-wheel brake circuit, if this is desired or required.

List of Reference Numerals:

1	electrical wiring system
2	front-wheel brake circuit
3	master brake cylinder
4	rear-wheel brake circuit
5	wheel brake
6	rotational speed sensor
7	master brake cylinder
8	front-wheel brake unit
9	steering rod
10	travel sensor
11	brake pedal
12	hand brake lever
13	working piston
14	wheel brake
15	cylindrical pin
16	central valve
17	pressure chamber
18	return line
19	supply tank
20	brake line
21	inlet valve
22	outlet valve
23	front wheel
24	control device
25	through-bore